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NEUTRON ACTIVATION OF GOLD DENTAL RESTORATIONS IN SMALL PRIMATE--ETC(U)
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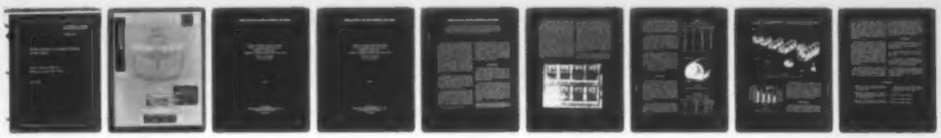

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SCHOOL OF AVIATION MEDICINE
RANDOLPH AIR FORCE BASE, TEXAS

JULY 1959

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Air University
SCHOOL OF AVIATION MEDICINE, USAF
RANDOLPH AFB, TEXAS

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ROBERT W. ZELLMER, Captain, USAF (MC)*
JACK L. HARTLEY, Major, USAF (DC)†
EVERETT O. RICHEY, B.S.*
NORMAN O. HARRIS, Lieutenant Colonel, USAF (DC)†

*Department of Radiobiology

†Dental Sciences Division

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Air University
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ROBERT W. ZELLMER, Captain, USAF (MC)*
JACK L. HARTLEY, Major, USAF (DC)†
EVERETT O. RICHEY, B.S.*
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*Department of Radiobiology
†Dental Sciences Division

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Air University
SCHOOL OF AVIATION MEDICINE, USAF
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# NEUTRON ACTIVATION OF GOLD DENTAL RESTORATIONS IN SMALL PRIMATES

**Dental gold alloys of various kinds were used to cast inlays which were placed in the molars of 10 small primates. These primates were then exposed to the neutron flux of an atomic detonation. The inlays were removed and the neutron-induced activity of the gold was measured in a scintillation counter. Calculation of the total activity showed a correlation with the neutron dosages received by the primates.**

Man now lives in an era of potential neutron exposure, of either civilian or military origin. To adequately plan treatment of such casualties, it becomes mandatory to develop methods for the early determination of the dose to which individuals have been exposed. Very little data are available whereby one can accurately relate dose of ionizing radiation and biologic effect on humans. In some cases, clinical symptomatology has been accurately described (1, 2), but the calculations of the dosages of ionizing radiation received were considered to have a large inherent error. In other instances, the dosages of therapeutic radiation are well known and the biologic effects adequately ascertained, but the subjects were not normal (3).

Since adequate human data relating early symptomatology to dosimetry are not available, the School of Aviation Medicine, USAF, has been conducting research in the acute and delayed biologic effects of ionizing radiation. In these studies the small primate has been the experimental animal of choice.

To make the continually accumulating data on the small primate more meaningful, a large-scale field study was conducted during the 1957 atomic field tests to relate the acute radiation syndrome in the small primate to that in man as it occurred in Japan under similar circumstances (4). As a phase of this large-scale study, a pilot experiment was conducted to determine whether there was a direct correlation of total neutron dose to the neutron activation of dental gold alloy restorations. This was prompted by the case report of one individual exposed to a lethal dose of neutron radiation in which dental gold restorations showed high activity (2). Histopathologic evaluation of oral tissues was also accomplished to determine the extent of cellular changes correlated with neutron dose.

## PROCEDURE

In preliminary studies cubes (3 x 3 x 3 mm.) of dental gold alloys[1] commonly used were placed in a reactor; results indicated that activation was proportional to the neutron flux. In vivo gold restorations of similar gold content and volume were expected to result in the same dosimetry correlation.

To test this hypothesis, gold inlays (equal in volume to the cubes used in the reactor experiment) were placed, under general anesthesia, in the second deciduous molars of 10 young small primates. Cavity preparations involved the occlusal surface only (class I). The animals were fed Extruded Monkey Pellets and water ad libitum. They were given no prophylactic or therapeutic medication either before or after exposure.

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[1] Three alloys were used: type II, inlay, containing 78.2 percent gold; type III, ¾ crown, containing 76.4 percent gold; type IV, saddle bar and clasp, containing 68.5 percent gold. (National Bureau of Standards Circular C-433. Physical Properties of Dental Materials and Federal Specifications for Dental Gold, QQ-G-540.)

The animals were flown by military C-54 aircraft to the test site. They were transported and housed in specially designed cages (fig. 1). On the night before exposure, the animals were placed in individual exposure cages (fig. 2) and carried to the field by truck. There the cages were inserted into large cans (eight individual cages per can) (fig. 3). These cans were painted with aluminum paint to reflect thermal radiation; and ⅛-in. aircraft cable was used to anchor them to position. Of the 10 animals exposed for this phase, 4 were in the first, or nearest position (group A); 3 were in the next position (group B); 2 were in the next position (group C); and 1 was in the fourth position (group D). Gamma radiation was measured by the chemical dosimetry method of Sigoloff and Logie (5) and neutron flux was measured by the fission foil system of Hurst (6). Animals, positions, and mean radiation doses are shown in table I.

The animals were recovered within one hour after exposure, and within twelve hours they were returned to the Radiobiological Laboratory. There, the teeth containing the activated gold inlays were extracted and cleaned prior to counting. The detector consisted of a well-type scintillation counter with a thallium-activated sodium iodide crystal (N. Wood Counter Laboratories Model SC-5L-120). The output pulses from this detector were counted with a conventional decade scaler (Technical Measurements Corporation, Model SG-2A) having an electronic scale of 1,000. The detector and scaler had a resolving time of $5.88 \times 10^{-6}$ seconds and a combined counting efficiency and geometry of 38.4 percent for gold-198 in the samples used.

The activity of the gold samples was measured a total of nine different times over a period of 11 days, at intervals when the decay

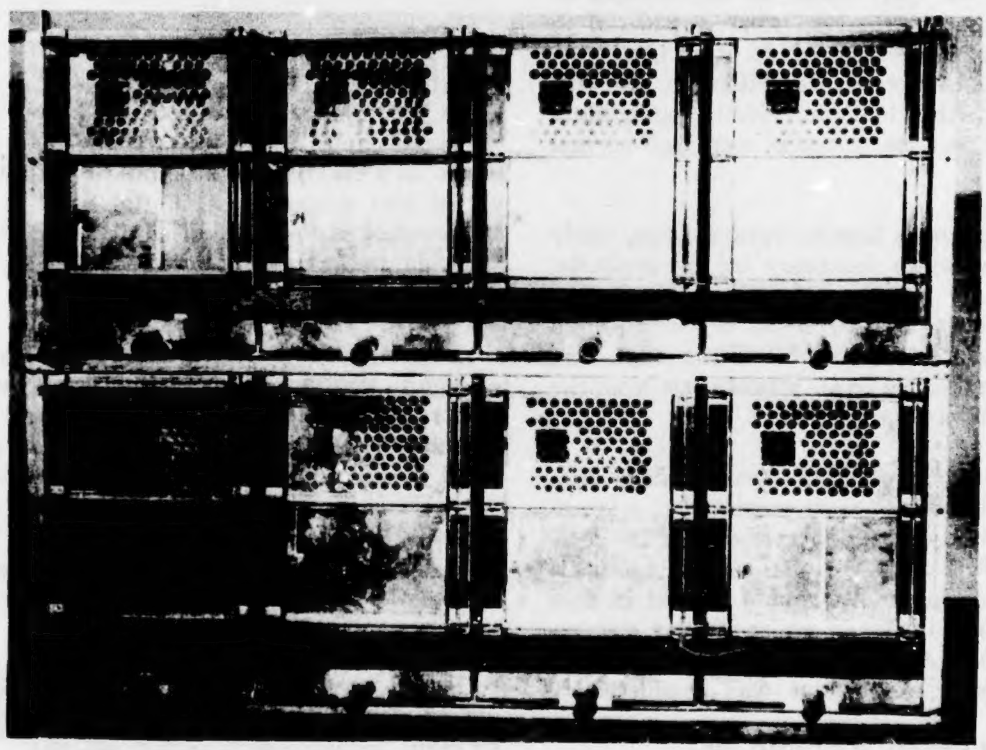

**FIGURE 1**

*Aluminum transport cages in racks.*

time ranged from 66.5 hours (1.03 half-lives) to 323 hours (5.0 half-lives). The first two measurements were made with the samples in the intact teeth; then the teeth were crushed and the inlays removed and cleaned for the remaining seven counts to eliminate any radiation from activated elements in the teeth per se.

The well of the detector was lined with 1/16-inch aluminum to stop all the beta particles and count the gamma emissions only. To measure the effect of sample position in the well of the counter on the counting rate, one sample was moved to new positions between successive counting periods. No measurable difference was found.

All animals of this phase died of acute radiation sickness within 11 days. At time of death the following oral tissues were removed for histopathologic examination: the tongue, condyle of the mandible, and the submaxillary, parotid, and sublingual glands. The parathyroid gland was also examined because of its influence on osseous metabolism. Formalin fixation and Harris's hemotoxylin and eosin staining were employed.

## RESULTS

The measured activities of the gold samples were corrected by standard methods for resolving time, geometry, counting efficiency, and decay time. The resulting activities for each sample at the time of exposure were then adjusted for the amount of gold per sample and the activity expressed as disintegrations per minute per gram of gold. The activities of all the samples in each group were combined to obtain the mean activity per gram of gold at each position.

Table II shows that the mean induced activity of the gold for each group of animals is proportional to the neutron dose in rep as measured by the Hurst fission foil technic. Figure 4 is a graphic representation of these data.

### TABLE I

*Neutron and gamma dose of each animal*

| Animal | Group | Neutron dose (rep) | Gamma dose (rep) |
|---|---|---|---|
| 690 | A | 522 | 516 |
| 710 | A | 522 | 516 |
| 732 | A | 522 | 516 |
| 774 | A | 522 | 516 |
| 749 | B | 470 | 446 |
| 753 | B | 470 | 446 |
| 755 | B | 470 | 446 |
| 762 | C | 423 | 386 |
| 765 | C | 423 | 386 |
| 823 | D | 381 | 334 |

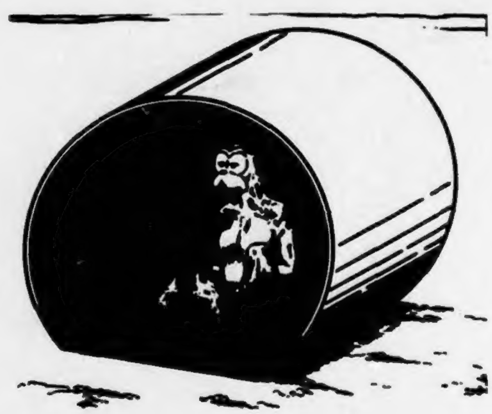

FIGURE 2

*Monkey in place in individual exposure cage.*

### TABLE II

*Neutron dose and gold activity*

| Group | Neutron dose (rep) | Disintegrations per min./gm. gold |
|---|---|---|
| A | 522 | $1.94 \times 10^7$ |
| B | 470 | $1.60 \times 10^7$ |
| C | 423 | $1.47 \times 10^7$ |
| D | 381 | $1.16 \times 10^7$ |

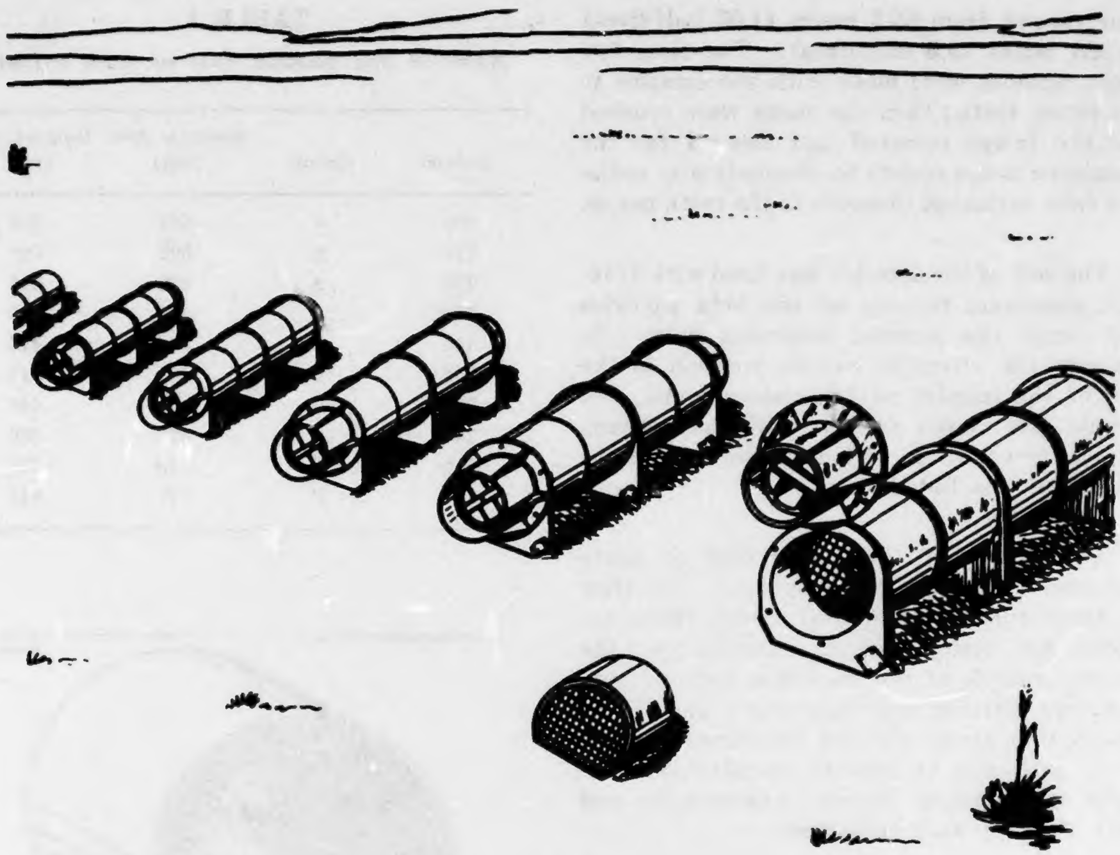

FIGURE 3

*Blast- and thermal-resistant cans in place in the field.*

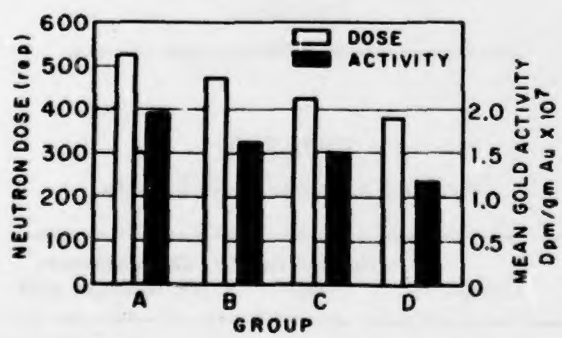


FIGURE 4

*Mean gold activity compared to neutron dose.*

Histopathologically, the selected tissues showed no significant differences from the normal, with the possible exception of the dorsum of the tongue. Here, in the two groups (A and B) closest to the center of detonation, the basal layer of the epidermis appeared to contain fewer cells with less orientation and a greater number of mitotic figures than seen in the more distant (C and D) groups.

## DISCUSSION

During the early periods following accidental neutron irradiation of an individual, it is difficult to accurately determine the extent of exposure. Even in one recorded case where

exposure and subsequent death occurred at a facility with specific capabilities for care of such accident victims, definite information on exact dosage was lacking (2). If in the future there should be victims of neutron irradiation, especially if mass casualties are involved, the problems of early triage and subsequent treatment planning would likewise be compounded by this lack of specificity of early symptoms.

Since the extent of neutron activation of gold is directly proportional to the dosage received, the resultant activity of such restorations in the oral cavity should indicate approximate exposure level. Of all the metals used in the usual dental restorative procedures, only gold has a sufficiently long half-life to be used for such evaluation. It is postulated, however, that a sufficient number of gold restorations are present in a random population to justify an oral survey as part of the physical examination of patients suspected of being exposed accidentally.

The differing percentages of gold in the various alloys, as well as the position in the oral cavity, appeared initially to be of importance. The resultant data indicated, however, that the neutron activation was proportional to the gold content of the alloys, regardless of position in the mandibular or maxillary dentition. Thus, the activity of the gold restorations can be used to calculate the extent of neutron flux. This can be accomplished immediately after exposure, whereas other tissue changes and resulting clinical symptomatology do not become apparent for quite some time.

## SUMMARY

1. Dental restorations of types II, III, and IV gold alloy, were inserted in teeth of small primates exposed to the neutron flux of a nuclear explosion.

2. The activation levels of the gold restorations were well correlated to the measured neutron flux.

3. The extent of histopathologic changes to selected oral tissues of the same primates did not parallel the correlation of neutron activation of the gold restorative materials.

4. The extent of neutron-induced radioactivity of dental gold restorations following a nuclear accident can be used to calculate the neutron dose before other definite clinical symptoms appear.

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